§15. Fundamental Study for Tungsten Material Based on Nano-scale for Fusion Devices

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Tungsten has widely used for face component for fusion device due to low sputtering ratio and high melting point. Especially, the material is very important for divertor part. Therefore, the surface condition of the tungsten has been required to realize not only its surface physics but also condition of high temperature plasma. In the field of the plasma-surface interaction, the surface study is utilized by scanning electron microscope to observe its surface and thermal desorption spectrometry to count the component inside the tungsten. However, the techniques have been required to remove the component from the divertor panel or collet the probe material in the fusion device.

On the other hand, nano-technology has been also used to understand local area less than micro-meter scale, called Nano-scale. And focused ion beam (FIB) is very powerful to sputter certain area and deposit thin film in situ, showing Fig.1

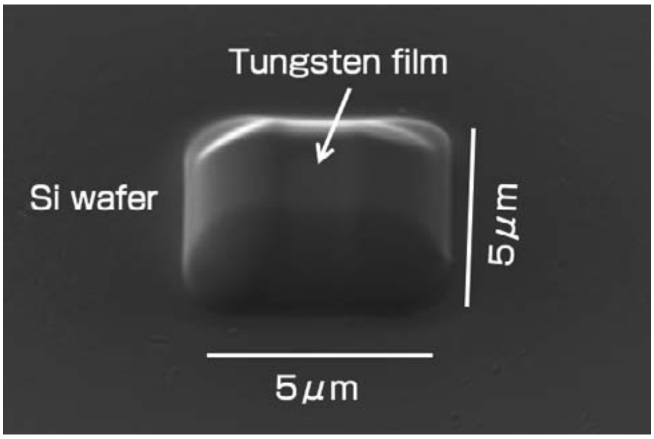

Fig.1 Tungsten film made by FIB on Si wafer

Here, we notice the film using chemical reaction between high energy Ga ion beam and $W(CO)_6$ gas has been used for local electrode by FIB, and the tungsten film deposited is changed to superconductor less than 10 K, depending on the impurity in the film.[1] Although the physics why the film can change the phase from normal to superconductor has been not cleared, the transition temperature is one of the indexes to realize the information on the surface of the tungsten. Especially, it is difficult to detect the low Z materials like H, He, C and so on by using conventional techniques. Therefore, we have proposed the transition temperature is one of the parameter to show the surface condition without any destruction of the tungsten by using resistance measurement in low temperature.

To do a demonstration, we prepared the cupper thin film pattered in inset of Fig. 2 and deposit the tungsten wiring (film) to connect each electrode by using FIB deposition. Then, the pattern was installed into the cryostat to measure the resistance of the wire made by tungsten. Figure 2 shows the temperature dependence from 300 K to 3.2 K by GM cryo-cooler. The resistance is almost flat from 300 to 5 K because the film may be a sort of amorphous. Under the 5K, the resistance is rapidly decreased and vanished at 3.7 K. We should notice the temperature for pure tungsten is less than 0.1 K. it shows the temperature for the tungsten film contained impurity was dramatically changed using resistance measurement.

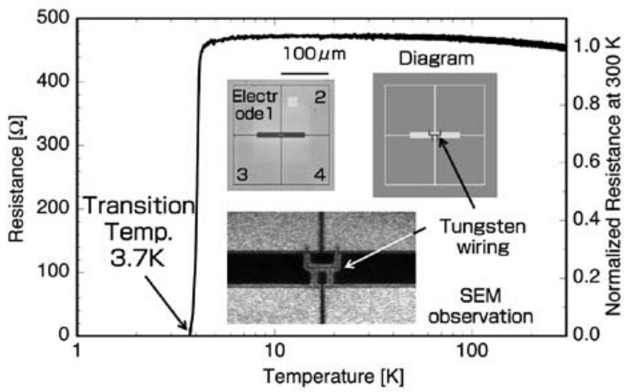

Fig. 2 Temperature dependence of the tungsten film between electrodes made by copper

As a result, the transition temperature is apparently dominant parameter to characterize the quality of the tungsten film, depending on the impurity. By using the energy dispersive x-ray spectrometry, the quantity of the impurity was carbon, which is nearly 50 %.

1) Sadki. E. S., *Appl. Phys. Let.*., 85, 6206 (2004)